

Transmission of HIV, hepatitis B virus, and other bloodborne pathogens in health care settings: a review of risk factors and guidelines for prevention

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Recent reports of the transmission of human immunodeficiency virus (HIV) in health care settings have caused considerable public health concern. HIV as well as hepatitis B virus (HBV) and other bloodborne pathogens do constitute infectious hazards in certain settings. Transmission has been reported from patient to patient, patient to health care workers, and rarely, from health care worker to patient. Although the risk of bloodborne pathogen transmission is largely preventable, it may occur due to the use of infected blood for transfusion, the use of improperly sterilized medical or dental equipment, and accidental punctures with contaminated instruments. The risk of transmission of bloodborne pathogens is dependent on a number of factors and appears to be greater for HBV than for HIV. General guidelines for the prevention of transmission in health care settings are given, including the concept of "universal precautions", the need for adequate supplies of sterile equipment, the reduction of unnecessary injections and transfusions, and the appropriate use of hepatitis B vaccine. In addition, areas for research are highlighted that could improve understanding of transmission risks in different health situations and provide the information necessary to develop more effective measures to protect both care providers and patients.

Introduction

The HIV/AIDS (human immunodeficiency virus/acquired immunodeficiency syndrome) pandemic has highlighted and exposed a number of public health problems that have not previously received sufficient attention. One such problem is the transmission of bloodborne pathogens in health care settings. Following requests from Member States for guidance on the measures needed to prevent such transmission, the WHO Global Programme on AIDS convened a consultative meeting on this issue in April 1991 (1). This article served as background material for the meeting and provides a framework for understanding the transmission of bloodborne pathogens in health care settings by reviewing the factors that affect transmission risk and providing guidelines for prevention. The legal and ethical implications are not discussed.

Bloodborne pathogens constitute a variety of infectious agents that can be transmitted via blood and sometimes other body fluids and tissues. Although HIV transmission has received the greatest amount of recent attention (2), transmission of bloodborne pathogens has been described in many

different health care settings and has been reported from patient to patient, patient to health care worker, and rarely, from health care worker to patient. Fig. 1 illustrates schematically the possible pathogen transmission pathways. Although the exact proportion of transmission attributable to particular pathways is not known, the majority of reports have described transmission from patient to health care provider or from patient to patient (usually facilitated by contaminated equipment used by the care provider). Secondary transmission can occur when an individual infected in the health care setting goes on to infect others in the community. For instance, a female health care worker may contract hepatitis B virus (HBV) infection from a needlestick injury and then transmit the infection to her husband, through sexual intercourse, and to their infant, through perinatal transmission.

Factors affecting transmission risk

Transmission of bloodborne infection requires an infectious source, a susceptible host, and the transfer of a sufficient dose of the infectious agent through the protective defences (skin or mucous membrane) of the susceptible host (Fig. 2). Health care procedures performed with proper infection control standards rarely if ever lead to transmission of bloodborne pathogens. Transmission may result when lapses in proper infection control or accidents occur, such as the use of unscreened blood for transfusion, the use of improperly sterilized medical or

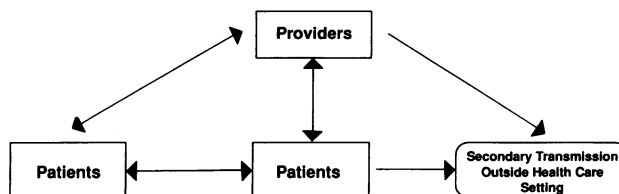
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Reprint No. 5217

Fig. 1. Possible pathogen transmission pathways in the health care setting.



dental equipment, accidental punctures with contaminated needles or sharp instruments, and exposure of nonintact skin or mucous membrane to infectious materials. The risk of transmission depends on the following major factors: the dose of pathogen transmitted; the infectious characteristics of the pathogen; and the frequency or probability of exposure to infectious material. Each of these is discussed below.

The dose of pathogen transmitted

The amount or effective dose of pathogen transmitted depends primarily on the mechanism of pathogen transfer from an infectious source, given a certain pathogen concentration and volume. One of the most efficient mechanisms of pathogen transmission is the direct injection of infected blood or blood products. Post-transfusion hepatitis and HIV infection are well-known occurrences that are documented in numerous sources (3–7). Since the development of diagnostic antibody tests for HBV and HIV, transmission of these agents through contaminated blood or blood products has decreased substantially in most developed countries and some developing countries. Bloodborne transmission of brucellosis, Chagas disease, cytomegaloviral disease, malaria, syphilis, and some less common diseases has also been reported (8–14).

The risk of infection after receiving large volumes of infected blood, e.g., from transfusions, is extremely high. It is difficult, however, to estimate

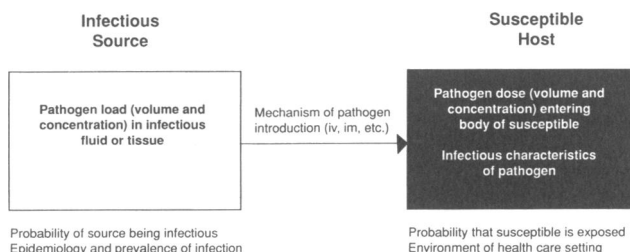
the minimal pathogen dose at which the risk of infection becomes significant.

Although the amount of blood in contaminated injection equipment is relatively low, the rapid spread of HIV through intravenous drug-using communities and the nosocomial transmission of HIV in eastern Europe attest to the efficiency of transmission from contaminated needles and syringes (15–19). Automatic fingerstick devices have been incriminated in outbreaks of hepatitis, even when disposable lancets were changed between patients (20, 21); apparently, small amounts of HBV-infected blood on the nondisposed parts of the device contaminated the lancets during use.

In addition to contaminated blood transfusions and needlesticks, other types of exposures may produce various degrees of risk for the exposed individual. Percutaneous exposures to pathogens can result from almost any blood-contaminated sharp object as well as from jet injectors that deliver blood-contaminated fluids through the skin (22). Although percutaneous inoculation may deliver a greater dose of infectious pathogens, transmission of HIV and HBV infection through contact of infectious material with mucous membranes or nonintact skin (caused by dermatitis, unapparent abrasions, or other lesions) has also been documented (23–26).

Although the mechanism of exposure will largely determine the volume of infectious blood introduced, the concentration of pathogen may vary greatly and is dependent primarily on the infectious characteristics of the pathogens concerned.

Fig. 2. Illustration of the factors that affect the risk of infection (iv = intravenous, im = intramembranous).



Infectious characteristics of pathogens

Infectious characteristics of pathogens include factors such as the usual biological range of pathogen concentration in blood and other body fluids, the resistance of the pathogen to the body's defences, and the length of time that the pathogen remains viable in the external environment. From available evidence, it appears that HBV is significantly more infectious than HIV. For example, it has been estimated that 7–30% of individuals sustaining needlestick puncture injuries from patients who are positive for hepatitis B virus surface antigen (HBsAg) became infected, compared with less than 0.5% of individuals sustaining needlestick injuries from HIV-infected persons (27, 28). Other reports support the relatively low risk of acquiring HIV from patient contact (29, 30). Although there have been several rare cases of care-provider-to-patient HBV transmission, there has only been one recent report of possible HIV transmission from a dentist to his patients in this manner (31–37). Whether these differences are also influenced by factors such as the disparate prevalences of HBV and HIV, as well as by the longer period of observation for HBV compared with that of HIV, is not well understood.

One reason for the apparent greater relative infectivity of HBV compared with that of HIV appears to be related to the higher biological viral concentrations of HBV. HBV often circulates at titres of more than 10^8 infectious doses per ml of blood (38–40), whereas HIV usually circulates in the range 10^3 – 10^5 infectious doses per ml (41). Hence, receipt of a large quantity of infectious blood, e.g., a full unit, would most probably infect a susceptible person with either HBV or HIV, but with exposures involving lower doses, the risk of HBV infection, relative to that of HIV, is probably greater. Other potential variables that may influence infectivity include the clinical and immunological status of both the infectious source and susceptible persons. As understanding about HIV disease improves, potential immunological markers (analogous to the HBsAg and HBeAg markers of HBV) could be used to predict infectivity in HIV-infected persons.

Although the major focus of discussion has been on transmission through blood or blood products, concern has been raised about the possibility of HIV and HBV transmission through other body fluids or tissues. Certain body fluids (not blood-contaminated), e.g., urine, saliva, tears, sputum, and sweat, are less infectious for HIV and HBV than other fluids that usually contain higher pathogen concentrations, e.g., semen, vaginal secretions, blood, and blood products (42). The amount of information concerning HIV and HBV transmission through body fluids other than blood, semen, and vaginal secretions is,

however, small. The risk from exposures to body fluids with low pathogen concentrations is probably minimal, with some evidence for rare transmission of HBV, but as far as we are aware, there is no such evidence for HIV (43–46). Similarly, there is no epidemiological or biological evidence to suggest that exposure of intact skin to body fluids presents any risk for transmission of HIV or other bloodborne pathogens.

Other characteristics that can influence infectivity include the resistance of the pathogen to the body's defences and the period of its viability in the external environment. For example, whereas HBV can remain viable for at least a week in dried blood, HIV appears to be less resistant (47–49). It is not clear how viral viability or infectivity is related to whether a virus is cell-free or cell-bound. Similarly, the ability of a virus such as HIV to mutate and evade immune responses or the capabilities of the immune system to react are other important factors that influence infectivity.

Probability of exposure

The probability that susceptible individuals are exposed to bloodborne pathogens in the health care setting is dependent on the following primary components: the prevalence of infectious pathogens in the population concerned or the health care environment; and the effectiveness of infection control practices in the health care environment. The prevalence of infection is usually not very amenable to significant short-term interventions but requires coordinated public health measures to decrease transmission. The second component, infection control in the health care environment, can be more easily modified.

In populations of patients where the prevalence of a given bloodborne pathogen is very low, the probability of contact with pathogen-infected blood is also low. However, in health care environments the prevalence of infectious agents in population groups is generally higher than that in the community. Different health care environments expose both patients and care providers to various levels of risk. Certain occupational settings create relatively high rates of exposure; for example, several reports have demonstrated increased risks of viral hepatitis infection among workers engaged in surgical, emergency, trauma, haemodialysis, and other activities where there is exposure to large amounts of blood and other body fluids, as well as to patient populations among which the prevalence of infection may be high (50–55). Laboratory, pathology, phlebotomy and blood-bank personnel are also frequently exposed to infectious material (56). An epidemiologi-

cal study showed that hospital housekeeping and laboratory personnel had the highest incidence of needlestick injuries (57), and an investigation by the Centers for Disease Control estimated that the annual risk of HBV infection was 2% for laboratory workers, compared with 1% for physicians and 0.7% for nurses (58). On the other hand, in routine inpatient and outpatient settings, where there is no significant contact with blood or other potentially infectious materials, the risk of infection is much less.

To modify and improve infection control in the health care environment, many health care facilities have taken measures to reduce the probability of exposure to pathogens by introducing strategies such as universal blood and body fluid precautions (59, 60). The concept of universal precautions is based on the assumption that all patients may be infected with bloodborne pathogens and stresses the importance of applying appropriate precautions to all patients and their body fluids. In most areas of the world where HBV is a major occupational hazard for health care personnel, hepatitis B vaccine provides a safe and effective means of protection (61, 62).

For the patient, substantial risks for pathogen transmission may occur when health care workers do not follow adequate sterile procedures and infection control. In some countries, needles and syringes are reused without proper sterilization. Among the reasons for improper sterilization practices are shortages of injection equipment, lack of fuel for sterilization, and inadequate training of personnel. In some cases, although a sterile needle is used for each injection, a sterile syringe may not be employed; reused syringes have been implicated in the transmission of hepatitis (63, 64). Recent nosocomial infection of children with HIV has demonstrated chains of transmission via contaminated blood or injection equipment (18, 19). Evidence from hospitalized HIV-positive children with HIV-negative mothers has shown that seropositivity was associated with an increased number of medical injections (65). In fact, in one country, the majority of AIDS cases in early 1990 are believed to have been acquired from HIV-infected blood or blood-contaminated injections (19).

As discussed above, screening has diminished the hazard of infection from transfusion of blood and blood products. However, in areas where screening of blood is unavailable or not performed for other reasons, the risk remains. This risk is increased when unnecessary or inappropriate transfusions are given (66).

Many health care programmes have taken steps to minimize the possibility of nosocomial infections by improving blood safety and stressing the importance of using a sterile needle and syringe for each injection. Also WHO has worked with manufac-

turers to develop improved and safer injection equipment.

While it is difficult enough to ensure the use of sterile procedures in mainstream health care settings, monitoring the use of injections, blood-letting, scarification, and various other skin-piercing practices in traditional and alternative settings creates additional challenges. The exact number of people seeking health care from traditional and alternative healers and the risk of infection in these settings is not known. Nevertheless, other recommendations for prevention may be required for such settings as well.

Summary and guidelines

The HIV epidemic has generated increased concern about bloodborne pathogen transmission in health care settings. Although the risk of transmission of HIV and other bloodborne pathogens is certainly real, it is largely preventable.

The risk of transmission of bloodborne pathogens appears to be highest from direct percutaneous exposures to infectious material with greater infectivity from pathogens such as HBV, rather than HIV. Although the transmission of HIV and other bloodborne pathogens in health care settings may account for a very small proportion of overall infection and transmission, the potential for such transmission always exists. Despite this unknown risk, the use of proper sterile procedures is sufficient to substantially reduce or eliminate it.

Prioritization of guidelines

Until recently, many recommendations for the prevention of transmission of bloodborne pathogens in health care settings in industrialized countries have assumed that substantial financial resources were available. In addition, some of the regulations have stemmed from socioethical, legal, and liability issues. Protocols for minimizing the risk of infection while maintaining patient and provider confidentiality have resulted in very comprehensive and often expensive recommendations.

In most developing countries, the resources for basic health care are strictly limited. Certain recommendations that are used in industrialized countries may therefore need to be modified in developing countries to yield practical and cost-effective prevention measures. All countries should assess the status of the health care environment as well as the epidemiology of bloodborne pathogens in their populations. If a significant proportion of infections occurs from the use of contaminated blood products or of unsterile equipment, prevention efforts should be focused in these areas. As discussed

above, general recommendations have been developed by a WHO consultation on the prevention of the transmission of HIV and HBV in the health care setting (1). The guidelines shown below, which are based on these recommendations, may be considered, especially for countries or areas with limited resources.

- The concept of universal precautions should be familiar to and used by all health care personnel. Blood from every patient should be assumed to be infectious and appropriate precautions taken. The HIV and HBV testing of health care providers and patients is not necessary for the prevention of transmission in health care settings, nor is it feasible to examine individuals on a routine basis to ensure that new infections have not occurred. Guidelines should be developed for the appropriate use of equipment such as gloves, gowns, and eye protection. Since most provider-patient interactions do not involve any risk of transmission of bloodborne pathogens, not all health care workers require such equipment. Therefore, priority should be given to those persons who are likely to be exposed to blood or body fluids.
- All health care centres and programmes should make available adequate supplies of syringes, needles, and other injection equipment. Training and supervision are important to ensure that all health care personnel are familiar with and use proper sterile techniques.
- Reducing unnecessary injections and other procedures should be a goal for all health centres. Also, the public should be informed about the dangers of procedures involving inadequately sterilized equipment, including traditional practices such as scarification, tattooing, and circumcision. The public should be educated to expect that all health care settings, whether mainstream or traditional, use proper sterile techniques.
- Criteria for the appropriate collection and transfusion of blood and blood products should be established and followed. In many areas of the world, blood is not collected from groups that have a low risk of infection and is not routinely screened; thus the risk of transfusion-related infection remains. Furthermore, since no screening test for blood components is 100% sensitive, the risk of infection can be further reduced by transfusing fewer units from selected donors (67). The development of safer and more effective blood transfusion services, including donor selection and more widespread screening, should be continued in all countries.
- Guidelines should be developed for the appropriate use of hepatitis B vaccine, which is the most effective method of preventing infection of susceptible persons with HBV. Whenever possible, hepatitis

B vaccine should be available for all health care workers at risk, i.e., those likely to come into contact with blood or certain body fluids. In populations or areas where the prevalence of HBV is high (Africa, Asia and the Pacific, eastern and southern Europe), routine immunization of infants with hepatitis B vaccine should receive priority.

- Increased interdisciplinary cooperation should be fostered in directing prevention efforts. Such efforts should support and build on existing infrastructures, such as national AIDS prevention and/or immunization programmes, to maximize resources.

Directions for research activities

In addition to immediate measures for prevention, research and development can provide improvements in infection control. Whereas there is already a basic understanding of the risk of transmission of infection, further research is needed in the key areas outlined below.

- Epidemiological investigations should be carried out to identify unusual modes of transmission, specific risks in different environments, and to investigate the circumstances under which infection control practices fail.
- Behavioural research will provide further understanding of injection practices, why infection control procedures are not followed, and how education efforts can be best directed.
- Research in new technologies is likely to present safer and more effective methods of injection (e.g., single-use syringes) and sterilization.
- Operational research is needed to help managers and policy-makers, especially in developing countries, to evaluate the most practical and effective strategies for infection control in health care settings.

With an improved understanding of the risks of transmission in different situations, more effective measures can be developed to protect both health care providers and patients.

Résumé

Transmission du VIH, du virus de l'hépatite B et d'autres pathogènes présents dans le sang lors des soins aux patients: analyse des facteurs de risque et directives de prévention

Des rapports récents faisant état de la transmission du virus de l'immunodéficience humaine (VIH) lors des soins aux patients ont suscité une

inquiétude considérable. Pour répondre aux Etats Membres qui demandaient des directives sur les mesures à prendre pour empêcher de tels incidents, le Programme mondial de Lutte contre le SIDA de l'OMS a organisé une consultation en avril 1991. Le présent article, qui constituait l'un des documents de base de la réunion, expose les grandes lignes du mécanisme de transmission des pathogènes présents dans le sang à l'occasion des soins aux patients, analyse les facteurs de risque et propose des directives de prévention.

Le VIH, de même que le virus de l'hépatite B (HBV) et d'autres pathogènes présents dans le sang, présente un risque d'infection lors des soins aux patients. Des cas de transmission d'un patient à un autre, d'un patient à un agent de santé, et plus rarement d'un agent de santé à un patient ont été signalés dans diverses circonstances. Bien que le risque soit largement évitable, la transmission est possible en cas de transfusion de sang infecté, de défaut de stérilisation du matériel médical ou dentaire, ou de piqûre accidentelle avec un instrument contaminé. Le risque d'infection dépend d'un certain nombre de facteurs et semble plus grand pour le HBV que pour le VIH. Bien qu'il soit difficile d'agir à court terme sur des facteurs comme la prévalence et l'inféctiosité des différents pathogènes dans le contexte des soins de santé, des mesures efficaces peuvent être prises pour limiter le risque d'infection.

Le présent article propose des directives générales pour la prévention de la transmission des pathogènes présents dans le sang. Les mesures préconisées consistent à adopter des "précautions universelles", à fournir du matériel stérile en quantité suffisante, à réduire le nombre d'injections et de transfusions inutiles, et à utiliser le vaccin de l'hépatite B à bon escient. La notion de "précautions universelles" part de l'hypothèse que n'importe qui peut être infecté par un pathogène présent dans le sang, d'où l'importance de prendre des précautions appropriées avec les liquides corporels de tous les patients. L'agent de santé et le patient doivent tous deux être conscients des dangers des interventions pratiquées avec des instruments mal stérilisés, et ils doivent pouvoir compter sur l'application des techniques appropriées de stérilisation, quel que soit le contexte dans lequel sont prodigués les soins de santé. L'examen systématique et/ou obligatoire des agents de santé ou des patients pour vérifier s'ils sont infectés ne constitue pas une stratégie efficace de lutte contre les infections transmises par le sang et n'est pas recommandé. Enfin, la poursuite des recherches dans les domaines de

l'épidémiologie, des sciences sociales, de la gestion, des nouvelles technologies, etc., permettra de mieux comprendre les risques de transmission dans différentes situations et fournira les informations nécessaires pour élaborer des mesures de protection plus efficaces, tant pour les agents de santé que pour les patients.

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